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University of Maine.

Maine Agricultural Experiment Station

ORONO

BULLETIN 254

SEPTEMBER, 1916

STUDIES OF LIFE HISTORIES OF FROG- HOPPERS OF MAINE

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†In collaboration with U. S. Department of Agriculture.

BULLETIN 254

STUDIES OF LIFE HISTORIES OF FROGHOPPERS OF MAINE.*

HERBERT OSBORN.†

MEADOW FROGHOPPERS.

The species of froghoppers common in meadows belong to two species, *Philaenus lineatus* and *P. spumarius*, which will be discussed in detail separately. Certain features are common to the two species but in certain respects they are very different. Both produce large quantities of frothy matter "spittle," and this is formed by liberating air beneath the fluid discharged from the anal opening. See figs. 48 and 49. This fluid evidently contains sufficient albuminous or gelatinous material to form a slightly viscid mixture so that the air liberated within it forms little bubbles that persist for a long time, some remnant of the frothy mass adhering to the plants for some time after the insects have emerged as adults and taken their departure. I am not aware of any study of the composition of the froth and it seems to have been assumed that the frothy condition was due to air in the fluid just as it is discharged from the alimentary canal. I have noticed however that there is a distinct secretion from the sides of the seventh and eighth abdominal segments, apparently a glairy or viscid substance, quite evident when the living insect is submerged in weak alcohol. It seems to be slightly coagulated but not dissolved in the alcohol and it appears probable that the addition of this substance to the discharge from the alimentary canal furnishes the viscid quality to the mass that is necessary to maintain its frothy con-

*Papers from the Maine Agricultural Experiment Station; Entomology 89.

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dition. This condition persists even during rather heavy rains, showing a certain insolubility in water as well as in alcohol. The glands from which the secretion comes are located laterally in the abdominal segments (the 7th and 8th) and in a specimen of one of the intermediate instars, probably the third, they appear as black spots. In other instars, so far as observed, they are not specially colored but show in mounted specimens as a more opaque area while the surface is roughened over a triangular area though no gland openings have been observed in the material studied. The pores may be too minute for ready observation. A similar secretion has been observed for *Clastoptera*.

The purpose of the frothy masses is generally assumed to be for the protection of the nymph and it is easy to see that they are pretty well guarded against many of the smaller kinds of enemies such as spiders and other arthropods. Some distinct adaptations associated with the habit are to be noted as for instance, the loss in large degree by the nymphs of the leaping habit and also the nearly complete loss of color.

That these two species have a distinct preference, if not a positive restriction to particular food plants is indicated by the fact that *spumarius* is taken almost entirely from plants other than grasses while *lineatus* is taken almost exclusively from grasses, especially timothy and redbtop.

As a test of their choice in this matter on July 9th ten individuals of *lineatus* were transferred from timothy to clover and of these none lived, though two had succeeded in changing to adult stage probably being very near maturity. In the reverse test ten specimens of *spumarius* were transferred from clover to timothy and only two lived to become adults, none made froth on the timothy and all showed restlessness and attempts to move. They evidently failed to secure sap and it is possible that there is some distinct difference in the mouth parts correlated with the different food plants as well as a difference in selection.

The economic importance of these species has been variously estimated though I think too generally overlooked. I find in an early record in the *Maine Farmer* for July 26, 1866, the following note by G. E. Brackett under the head of "Practical Entomology:"

"About 'Hoppers.' There is a class of insects including three families, the leafhopper, treehopper and froghopper, which present some peculiar characteristics, the species most common here is the froghopper (*Cercopida*) so called. Every farmer will have noticed upon plants, particularly on grass, a mass of foam or spittle-like substance, adhering to the stalk, and containing an insect, which, from the fact that it leaps when disturbed, may have been called a young grasshopper. This is the froghopper, of the order Homoptera, and entirely distinct from the grasshopper, in having a tube to suck juices instead of jaws to bite leaves, as do grasshoppers and all other orthopterous insects. These froghoppers hatch from eggs laid in the previous autumn, and immediately puncture the tender bark of the plant with their beak and suck out the sap. They take in such large quantities that it oozes out of their bodies in the form of minute bubbles which soon form a covering of foam or spittle-like substance, which gives it its name. This substance shelters it from the sun and also from insect enemies. When they become full grown in autumn they are not thus protected, but are found moving about on the plants where they lay their eggs. A description of this insect will be unnecessary, as every reader has seen them. There is general resemblance among the different families of hoppers. They are not considered particularly destructive to the plants on which they are found."

In speaking of the injuries of the spittle insects Dr. Lintner (Fifth Report on the Injurious and Other Insects of the State of New York, p. 246, 1889) remarks as follows:

"Report has been made in Vermont of one or more of the grass infesting species causing considerable damage to the hay crop. It was estimated that in consequence of the depredations, the quantity of hay grown on some fields was one-third less than the natural yield, not including the depreciation in the quality of the crop. It is but seldom however, that these insects increase to such an unusual extent as to become of serious injury, and it is therefore unnecessary to indicate any means for their destruction. A gentleman, who asks for information regarding them, states that, in passing through his mowing fields, in Auburn, Mass., they are so numerous as to wet his shoes. An abundance such as this would of course, be harmful to the crop but, fortunately it is of rare occurrence."

Occurrences such as these are perhaps less rare than is generally supposed since these insects are easily overlooked and the tendency has been to give little heed to the attacks of insects unless they are severe enough to cause a very complete destruction of a crop. I am informed by Dr. Patch that occurrences where the insects are abundant enough to wet ones shoes in walking through grass are not infrequent and in my collecting the present season I have found them plentiful enough for this

purpose and often plentiful enough so that my net would become wet while sweeping the grass for specimens. As shown elsewhere by actual counts and estimates the drain on certain fields is such that it well deserves attention and the determination of measures for control.

If old fields showed uniformly small plants there would be some reason to attribute the reduction in growth to the soil or to "running out" but when scattered stems stand at good height and produce excellent heads it seems that this explanation is insufficient.

It is a peculiar sight in some fields to note a considerable number of tall well developed stalks with large heads in full bloom and along with them in exactly the same soil and exposure to sun, rain and other conditions, numerous dwarfed plants with short, blasted heads or no heads at all.

While some mention of the species has been made by these earlier writers there has been scarcely any reference to the species or their possible economic importance by later writers and there is evidently opportunity for some careful observations and experiment to determine their habits and possible measures for control. The observations recorded here it is hoped will furnish a basis for any more detailed studies that may be possible in the future, but they will serve, it is believed an immediate purpose in suggesting some measures which should help in the reduction of the losses from this source.

MEADOW FROGHOPPER.

(*Philaenus spumarius* L.)

This extremely abundant species is widely distributed in the eastern United States as well as in Europe. It is probably the species most commonly referred to in mention of frog-hoppers although the nearly related species *P. lineatus* has been doubtless often the basis of comment. In general works the two species are seldom distinguished but since they have a different food plant range and other differences in habit, a more exact reference seems desirable. In common usage froghopper covers both these and certain other species. To make a more precise distinction I would propose this species be called the

Meadow Froghopper and the *Philaenus lineatus* Grass-feeding Froghopper.

The distribution of the species covers the northern United States west to the plains region at least and in Maine its occurrence may be expected throughout the entire state. In fact it is one of the most abundant species encountered in meadows and pastures and it is found occasionally in cultivated fields of oats.

There is a quite wide range of food plants including many of the compositae as well as several cultivated crops. Among the food plants specially noted were buttercup, yarrow, thistle, helianthus, orange dock, daisy, clover, primrose, chokecherry and plum.

Its economic importance is of course considerably affected by the fact that many of its foodplants are noxious weeds and if it would confine its attacks to such plants it might be counted very useful but since it feeds abundantly on clover its presence in meadows must be counted detrimental.

In life history the species agrees very closely with *P. lineatus* so much so that one statement will almost answer for the two.

NATURE OF THE INJURY.

The effects of the attacks of this species are most apparent on the blossoms or the seed formation and in many cases are very evident. This is especially evident in the case of the buttercup which seems to be one of the favorite foodplants. Buttercup heads were marked to indicate those blossoms that were on stems attacked by the hoppers and four marked heads on a plant that bore eight other heads. The four attacked all withered and failed to produce seed while six of the others formed good seed heads and the other two were still in blossom at time the observation closed. See figs. 44 and 45.

Clover blossoms also show the same effect and there is no doubt that the hoppers must be a distinct factor in the reduction of the formation of the perfect clover heads.

Where buttercup is present *spumarius* seems to gather on it in preference to other plants though clover is apparently nearly as much affected.

LIFE HISTORY.

As already indicated the eggs of this species are believed to pass the winter in the meadows where the nymphs are observed in summer and probably they are found in the stems of their various food plants or possibly in dead stems or leaves at the surface of the ground.

The larvæ hatch in early summer, the earliest record which we have for the season of 1916, being June 13. The nymphs were mostly well along at the time of my first field observations in June and I conclude that the rate of growth is rather rapid for the latter part of June as during this time and early July but few less mature than the final instar were to be found. On July 10th these last instar individuals were still plenty on buttercup and a recently emerged adult was observed on dandelion. From the middle of July only adults were observed but these were evidently still feeding and it is certain that mating and egg development are carried along slowly. Mating was observed July 28th, and at this time adults of both sexes were abundant in clover in a meadow. One mated individual, dissected showed no evidence of egg development beyond the most immature formation and no indication of shell. By the middle of August egg development has proceeded so that occasional eggs are found with well formed shells but usually only a few mature eggs along with many imperfect and undeveloped ova in the oviducts. Figure 46 shows this condition as noted in a specimen dissected in August. The large black bodies are the eggs with shells and the faint ones those still unformed. The large spermatheca may also be observed above the ovipositor. No spermatozoa could be detected in the spermatheca but from its size it would seem quite certain that they must be retained for some time and the eggs are fertilized as they mature through a long period possibly several weeks during late summer and early autumn.

No egg deposition was observed before my leaving Maine the last of August and the only eggs seen were those dissected from the females during August.

DESCRIPTION OF EARLY STAGES.

Egg: The egg is moderately elongate, irregularly elliptic, about three times as long as broad, narrowing to one end, slightly flattened, one side straight or slightly incurved the other convexly curved, giving the egg a slightly curved appearance. The shell is tough and hard and developed while the eggs are still in the ovariole ducts.

The first instar observed is from two to three millimeters long, the head before the eyes strongly inflated semiglobose or bulbous, polished, with faint arcs on the front. Antennæ short, 8- or 9-jointed, first joint short, 2nd large, 3rd cylindric, 4th to 9th tapering, eyes dark, a distinct transverse furrow or suture across vertex between bases of antennæ. Beak reaching to third pair of legs.

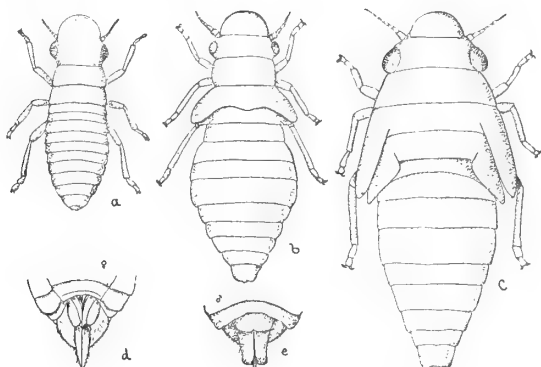


Fig. 38. *Philaenus spumarius*, a, young nymph; b, intermediate; c, last instar, all enlarged; d, female; e, male, genitalia. (Original.)

The second instar observed (possibly the 3rd in full series) has the head cordate, front bulbous, a depressed suture from antennal bases, forming a distinct transverse furrow, antennæ 9-jointed; 1st short, 2nd large, short cylindrical, 3rd longest cylindrical, 4th to 9th tapering gradually to tip. Eyes dark brown, reddish on the margins. Prothorax cylindrical; mesothorax expanded at sides to form beginning of wing pads, wider than metathorax slightly produced posteriorly, tips reaching nearly to hind border of the metathorax, hind border slightly curved, metathorax slightly expanded at sides, hind border

nearly straight, transverse; legs not distinctly spined, a few weak points at tip of hind tibiae. Abdomen widening to 3rd segment, tapering to tip, valves distinct. Length, 4 mm.

In the final instar observed the head is distinctly more pointed though the front is decidedly bulbous, ocelli are evident, the wing pads have developed backward so as to include the first two abdominal segments, those of the mesothorax being appressed to those of the metathorax and reaching almost if not quite to their tips. Head with vertex produced, subangulate, a depressed furrow crossing between the bases of the antennae, ocelli slightly nearer the hind border and about equally distant from each other and from the eye. Antennae 9-jointed, those following the third becoming more slender and setaceous. Eyes narrower, the larger part visible from below, red-brown appearing transversely barred, front tumid, clypeus strongly convex, beak reaching to behind 2nd coxae. Two rows of black spines at tip of hind tibiae. Length 5 to 6 mm.

This species is quite easily distinguished from *lineatus* in the final instar by the difference in the shape of the head. In *spumarius* this is distinctly wider than long so as to appear bluntly pointed and the transverse furrow is longer than the distance from its center to either the front of vertex or to rear margin. The body as a whole appears broader and the color is usually fairly distinct, *spumarius* having a yellowish tint while *lineatus* is green with dusky or smoky tint.

The adults present many varieties and most of these have been found in Maine. Several are figured in the accompanying plate (fig. 47) which shows also at bottom one of the nymphs.

There is apparently no relation in these varieties to the food plants as different varieties have been found to mature from nymphs feeding on the same plant. Furthermore individuals of different color varieties are found mating together, apparently without any reference to color pattern.

The typical form of the adult is easily seen from the figures, the head bluntly angular, the body elongate oval, widest about the middle, the elytra extending well beyond the end of the abdomen and the length from five to six millimeters. The color varies from pale gray to black and the markings in the form of irregular spots, broken cross bands, or longitudinal stripes.

GRASS-FEEDING FROGHOPPER.

(Philaenus lineatus L.)

This species appears to be a distinctly grass-feeding species and as noted in the preceding section seems unable to maintain itself on plants outside the grass family.

The species has a wide range in the northern hemisphere occurring over a wide territory in Europe and North America, but in the United States appears to be distributed especially through the northern portion, occurring from Maine to the Rocky Mountains. It seems to occur in greatest abundance in the New England States and, in meadows which are kept in grass for a number of years in succession, it undoubtedly must be ranked as a distinct pest. While seldom if ever alone in its attacks, being associated with various jassids and other sucking insects, it is one of the abundant forms and during the two seasons in which I have had opportunity to observe it there has been no question as to its numbers being sufficient to occasion distinct loss. The records of injury to certain fields apply with special emphasis to this species as it was so plentiful that the frothy masses were a conspicuous feature of the meadows in June and early July. Timothy and redtop were apparently about equally sought and the froth masses occurred from the level of the ground to several inches above.

The withering of the upper part of the stems and probably a considerable part of the blasting of the heads, some of which is doubtless due to thrips (*A. striatus* Osb.) or to Jassids may be attributed to this attack.

At the time of my arrival in Orono, the last of June, the nymphs had largely reached the final stage of growth so that I do not have observations on the earliest appearance. Judging by their maturity however and also by the stages of growth shown in the related *P. spumarius* it is probable that the eggs hatch and larval life begins in late May or early June.

On June 27th, 1914, at my first opportunity for personal observation the species was found plentifully on timothy and redtop, all found being in the nymphal stages and included in the froth masses, sometimes as many as two or three of the froth masses and included larvæ on a single grass stem. The most

mature at this time was one with the wing pads developed evidently in the final nymphal instar. The final instar occupies a period of two or three weeks and corresponds closely with the time of rapid growth and formation of heads in the grass, the nymphal stage being passed and adults beginning to appear at about the time of hay cutting July 3rd to 10th.

The mature nymphs are easily distinguished from those of *spumarius* by the more slender body, the narrower front portion or inflated part of the head and by a more dusky coloration, especially as they approach moulting.

The process of emergence is interesting and apparently varies slightly in different individuals, but in cases observed the emergence occurred within the froth masses. The nymphal case is included within the remnant of the froth mass that remains attached and clings to the grass stem for some time. The head is closely appressed to the stem and directed toward the upper part of the stem, the abdomen is elevated and this and the thorax are both split along the dorsal line. The front legs clasp the stem, but the middle and hind legs are free.

The remnant of froth mass retains closely the original form and shows the form of individual bubbles, a condition which certainly points to the presence of some content that gives a gelatinous consistency to an otherwise watery mass.

The full life cycle of this species has not been followed and there are several points in the cycle which it will be especially interesting to determine. Nevertheless, enough is known concerning certain of the most critical periods of development to furnish a basis for the application of certain measures of control.

That the winter is passed in the egg stage as has been generally stated and is evidenced by the occurrence of larvæ in our cages, placed in early spring over timothy grass in meadows. Adults certainly could not have entered there to deposit eggs in spring and if adults had hibernated in the grass we should have found some at least of the dead bodies present within our cages.

The date of egg hatching cannot be given precisely, but the earliest appearance of the froth masses in June would indicate a rather late hatching, at least for this latitude.

During June only young are to be found and during this period they pass through three or four moults. Three instars at least are represented in material collected June 19th, 26th and 27th.

In rearings from nymphs collected on grass the latter part of June adults were secured during the first week in July. In one case a nymph enclosed June 29th moulted July 1st and emerged as adult on July 5th and in another case a nymph probably recently moulted caged July 9th, developed to maturity and adult emerged July 11th. These all indicate a short nymphal period and rapid growth.

The adults continue to feed and up to July 29th no signs of egg maturity or egg deposition had been noted. Egg development is evidently slow and mating and egg deposition must occur irregularly, probably extended over a period of some weeks in autumn.

Ovaries from females, collected in the field, were dissected and four well developed eggs were found with definite shell, but no evidence of segmentation. A number of apparently undeveloped eggs were in the ovarioles.

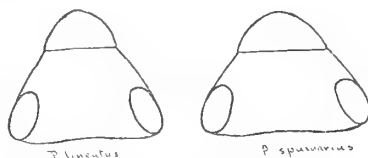


Fig. 39. Relative form of head in *Ph. lineatus* and *spumarius* nymphs of final instar.

Comparing the final instar especially with *spumarius* the head is longer and the front more distinctly produced. In *spumarius* the part in front of the suture is in the ratio of 10 to 24 while in *lineatus* it is as 11 to 20 and the head entire in *spumarius* is in ratio of 44 wide to 31 long in *lineatus* as 40 wide to 34 long as taken in average for several specimens.

Lineatus is further distinguished by the dusky coloration especially toward the posterior end of the body as the nymph approaches maturity.

Some very small specimens of this species were taken at Saddleback Lake in the summer of 1916, the smaller ones only

4 mm. long, and many froth masses were noticed on the small dwarfed plants of Canadian bluegrass growing on rocky ledges. It seems possible that the depauperate condition of the grass and of the froghoppers living on it may be a mutual adaptation to a deficient food supply.

Adults of *lineatus* are distinguished from *spumarius* by the narrow, more parallel sided form and the longer head. The head is rounded angular in front and as wide as the thorax.

The color is gray with a whitish margin to the costa, bordered by a blackish line which fades out toward the end of the elytron. The length is from four to five millimeters.

REMEDIES OR CONTROL.

It seems very evident that the most effective control for this species lies in a frequent rotation from grass to some other crop and the general freedom from infestation in timothy meadows not older than two or three years as compared with the great abundance in old meadows, emphasizes this point.

This applies of course to many other of the grass insects, but on account of the restrictions of this species and the fact that the time during which eggs must be present is extended over a long period, it should be particularly effective. To be of greatest advantage plowing should be done in spring or late in fall.

It is recognized that there are many situations especially in wooded pastures and rougher meadow land where it is desirable to maintain a grass crop for a long succession of years and it is hoped that measures for reducing or eliminating these pests will make this possible without sacrificing such a large percentage of the crop.

Of the measures available for permanent meadows three seem worthy of mention and thorough trial.

While egg deposition has not been actually observed it is almost certain that the eggs are placed in grass stems and that they remain during fall, winter and early spring in this condition. It will be evident that burning of the surface dead grass, when this is allowable, will furnish a means of destroying the eggs of these and many other species.

Hopper dozer treatment immediately after haying to catch recently developed adults, would probably be the best time for use of this measure.

The hopper dozer method consists in the use of a strip of sheet iron, ten or fifteen feet in length, coated with coal tar or tanglefoot, and drawn over the surface of the grass land with about the rate of a rapid walk. Its success depends upon the fact that the hoppers when disturbed jump up a few inches from the grass and this means that they will usually fall back upon the sticky surface and be caught. The tar or tanglefoot must be replaced as often as it becomes so loaded with insects as to permit them to escape.

Early mowing would probably reduce the number materially and where the insects are abundant the gain in later growth would probably compensate for loss in quantity of crop. A trial of this was attempted, but circumstances delayed the first mowing till the bulk of insects were ready to become adult, so no conclusive results were secured.

That such mowing would be of service is indicated by the entire absence of these insects on lawns where early and frequent mowing is the practice.

ANGULATED FROGHOPPER.

(*Lepyronia quadrangularis* Say.)

This species is not an abundant one in Maine, and apparently has no particular economic importance, but since it resembles the common meadow froghoppers it is desirable to show its distinctive characters.

It has not been observed, except in the latter part of the season, and so far as present evidence shows, there is a much belated single brood in the latitude of Orono, the larvæ of which develop during August, the adults being present during late August and through Sept.

Nymphs were first collected Aug 14th and included three well marked stages, representing evidently different instars and probably the second, third and fifth if the full series includes five instars. Adults appeared in the fields on the 18th, and a reared specimen was secured on the 17th from the nymphs collected on the 14th.

The nymphs are included in froth masses similar to those of the other froghoppers and are smooth and highly polished light green in color, becoming slightly more yellowish in later stages, the head distinctly blunt, almost truncate in front and the front somewhat flattened as compared with the bulbous form of the species of *Philaenus*.

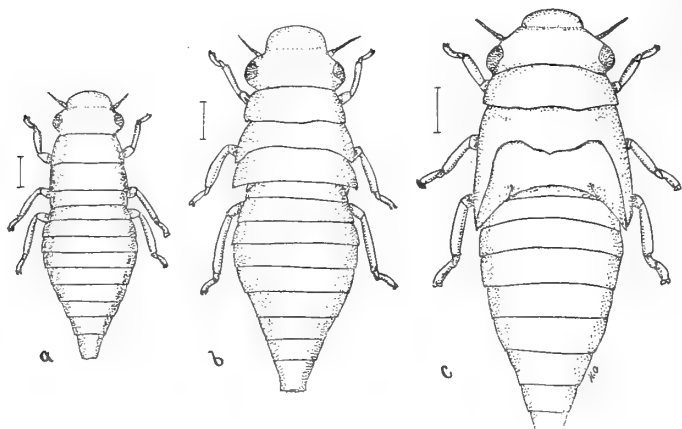


Fig. 40.

The smallest individuals taken (2nd instar?) *a*, Fig. 40, are 4 mm. long, tylus broad and distinctly truncate, beak reaching base of abdomen, the meso- and metathorax with no distinct development of wing pads, the color light green. The abdomen is pyriform, a little wider on third segment than thorax, the legs nearly uniform in size, the third pair slightly larger.

The next larger individuals (3rd instar?) *b*, Fig. 40, are 5-6 mm. long, similar in shape and color to the preceding stage, but with the wing pads clearly indicated, those of the mesothorax extending only slightly over the hinder ones, the beak reaching to the third coxæ.

The final nymphal instar (5th?) *c*, Fig. 40, is 6 to 7 mm. long, based on measurement of three individuals, light green in color with slightly more of yellowish and with the wing pads which extend to base of third abdominal segment of yellowish or whitish color. The beak extends to base of third coxæ, the legs nearly uniform in size, the hinder pair only slightly larger than the middle and the middle a trifle larger than the front

pair, the head is broadly cordate, the eyes prominent, and the front similar to the preceding stage with a slight production of the anterior border.

In all stages the pleural lobes of the abdominal segment are very large and occur on all segments to last, enclosing a broad, deep channel which, as in related species, doubtless serves especially in the enclosing of air to form the froth mass.

This species is often taken in autumn in sweeping in grass lands and probably has a variety of food plants, though so far the nymphs have been found only on the *Impatiens biflora*. The adults have been taken only in autumn and while it would be unsafe to say that no spring generation occurs, the facts at hand would indicate that there is a late deposition of eggs in fall and that these eggs remain unhatched until midsummer of the following year, then producing nymphs during August, or possibly in late July, which mature very rapidly and give rise to adults by the middle of this month.

While the nymphs of this species very closely resemble those of *Philaenus* they may be at once distinguished by the blunt form of the front part of the head, appearing from above as if the head had been pushed against some object and a circular form made broadly truncate.

Adults of this species have a quite characteristic appearance with strongly sloping elytra which bear a blackish marking, the angle of which touches the costal border. The general color is gray with often a dull suffusion of purplish or brownish tint. Length 6 mm. to 7 mm.

BUSH AND TREE FROGHOPPERS.

PARALLEL SPITTLE INSECT.

Aphrophora parallela Say.

Although this insect is a very abundant one and has been known to American entomologists for nearly a century, there has been very little written about it nor any careful study of its life cycle and habits.

About the only account of its habits worthy of mention is the original description by Fitch published in the Transactions of the New York State Agricultural Society for 1857.

This account is brief and while it has been reproduced in Packard's Forest Insects neither of these works is so generally available at present as to be accessible to all who might wish to see it, and it seems desirable therefore to quote it here.

"In June, a spot of white froth, resembling spittle, appearing upon the bark near the ends of the branches, hiding within it a small white wingless insect having six legs, which punctures and sucks the fluids of the bark, and grows to about a quarter of an inch in length by the last of that month, and then becomes a pupa of a similar appearance, but varied more or less with dusky or black, and with rudimentary wings resembling a vest drawn closely around the middle of the body; the latter part of July changing to its perfect form with wings fully grown, and then no longer covering itself with foam, but continuing to the end of the season, puncturing and drawing its nourishment from the bark as before. The perfect insect, a flattened oval treehopper, 0.40 in. long, with its wing covers held in form of a roof, its color brown from numberless blackish punctures upon a pale ground, a smooth whitish line along the middle of its back, and a small smooth whitish spot in the center of each wing cover, its abdomen beneath rusty brown."

This short account while giving the main points in the life cycle of the insect leaves many points to be desired and it was in hopes of supplying some of these wanting details that observations were begun upon the species in the summer of 1914.

At this time the nymphs in their frothy masses were quite plentiful on the Scotch Pines on the University Campus and it was hoped that by watching their development to verify the connection between these nymphs and the adult form. As stated by Fitch the nymphs were attached near the tips of the twigs and their presence was made very manifest, not only by the frothy masses, but by the sappy exudations running down on the branches so that there was a distinct discoloration. Usually only one nymph was observed on a twig and these were scattered over the tree. A number were enclosed in cheese cloth coverings to secure adults, but most of these were removed by some one who evidently counted them unsightly. However the rearing of some individuals and the securing of others either in process of emergence or in close proximity to the cast off skins leaves no question as to the larvæ observed being the young of this species.

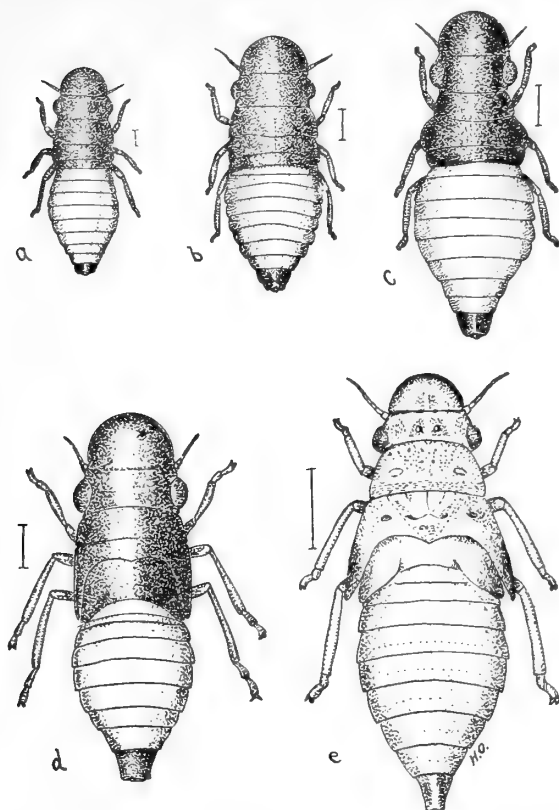


Fig. 41. *Aphrophora parallela* a, b, c, d, e, 1st, 2nd, 3rd, 4th, 5th instars. All enlarged. (Original.)

The earliest nymph collected in 1914 was a partly grown one secured by Mr. Newman June 19th, evidently representing the next to the last instar as all the later and larger nymphs showed a different color pattern. The date of egg hatching is therefore uncertain, but is probably during the last of May or early in June. The nymphal growth must be fairly rapid as individuals of the last instar occurred in early July and the first adults were observed on the morning of July 15th, one male being caught and another observed. At the same time one of the earlier instar forms was observed but at this time nearly all were in the preimago stage.

For the summer of 1916 which was late and the insects probably delayed in development, specimens were secured June 14th,

that represent still earlier stages and the smallest an individual but three and one-half millimeters long is probably the first, while a larger one, four and one-half millimeters long, may represent the second instar. These complete a fairly regular series from which we may present a brief statement of distinctive characters.

DESCRIPTION OF EARLY STAGES.

First instar. Smallest individual seen, length 3.5 mm. Body slender, abdomen scarcely wider than thorax. Head and thorax with antennæ and legs and the last segment of the abdomen black polished. Abdomen except last segment yellow. Antennæ short, first joint thicker, about as long as thick, second scarcely longer than first, enlarging to tip, third short and with the following joints forming an obscurely segmented terminal part, tapering slightly to a blunt tip.

The second instar as indicated by size and maturity is 4.25 mm. long with the color as in the first instar, but with a very slight indication of beginning of the wing pads of the mesothorax.

The third instar 5 mm. long has the coloration of the preceding stage, but there is a distinct enlargement of the mesothorax into developing wing pads, but scarcely any for the metathorax.

Fourth instar. Length 6 mm. Head strongly produced semi-circular from the base of the antennæ. A transverse suture across head, touching bases of antennæ. Mesothoracic wing pads extending back and enclosing metathorax and nearly touching base of abdomen, metathorax strongly concave behind the wing pads, not specially developed.

Color: Head and thorax including wing pads fuscous or nearly black, shining. Segments of the abdomen except the terminal one yellow-white, terminal segment black, tubular, legs black, tips of femora paler. Beneath; front black, lower part of face, legs and central stripe of abdomen brown, sides of abdomen, segments 1 to 5 orange red. (See fig. 41 *d*.)

Final instar. Length 11 mm., width 4 mm. Yellowish white with brown spots, brown eyes, ocelli in brown spots. A pair of spots on the prothorax, median and lateral spot on scutellum, part of mesothorax, the border and a pair of spots near center and the hind borders of the wing pads dusky; terminal seg-

ment black. Antennæ, eyes, tip of beak, and tarsi blackish. Ventral expansion of the pleurites giving a broad channel beneath, narrowing to tip where they form the leaf-like plates used in enclosing air to form the bubbles. (See fig. 41 *e.*)

ALDER SPITTLE INSECT.

(*Clastoptera obtusa* Say.)

This common species abundant over a large part of the northern United States has been known for a long period and while described and credited to alder it is found on a variety of plants mostly shrubs. Considerable confusion has occurred in its classification and Fitch described certain forms as *pini* and *testacea* from rather marked forms occurring on different plants, but Ball in his review of the group referred all these to *obtusa*. No distinct varieties have been clearly demonstrated as restricted to any host plant.

Linter Fifth Report of the State Entomologist of New York gives an account of the species based on larvæ occurring on alder. He describes the larvæ as nearly white with long

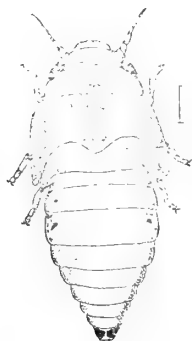


Fig. 42. *Clastoptera obtusa* Say. Nymph of last instar. Enlarged. (Original.)

legs which were moved rapidly in walking. The pupæ (last nymphal instar,) which had but recently undergone their transformation, show but little coloring, especially on their wing pads. With increased age they become more deeply colored, and they are olive-green on their thorax, wing cases and legs."

While the observations of this season add little to the past records, the fact that specimens were bred from white birch and hazel seems to make a record worth while.

Our specimens were taken as last instar nymphs on July 25th at which time they were beginning to change to adults and adults have been common on various plants since to early August. See fig. 50, *e* and *f*.

Records carry the species as adult as late as Sept. 5th, so it may be considered certain that there is a single generation in this latitude and that the winter is passed in the egg form, the eggs hatching in spring or early summer, probably in June or early July, and the larval stages are passed rapidly.

DOG-WOOD SPITTLE INSECT.

(*Clastoptera proteus* Fitch.)

As the specific name implies this species is extremely variable and occurs in several forms, the more common ones being black in color with bright yellow cross bands on the thorax, in some cases with bright yellow spots on the base of the elytra and in others without these spots. See fig. 50, *g*, *h*, and *i*.

The species is supposed to occur on a variety of plants, but at Orono it has been taken for the larval stages, especially on the dogwood. Nymphs of apparently the final stage were taken during the summer of 1914 and adults were reared from these of both the color varieties. In 1916 still younger nymphs, the smallest found about two millimeters in length, were taken on dogwood and these are the smallest that have been secured. These were taken July 2nd, 7th and 10th and represent evidently individuals that have hatched from eggs that have survived the winter as no trace of earlier generation or of hibernating females has been found. These earlier nymphs agree closely with the older nymphs observed in 1914 except that the head and thorax are nearly black or solid dark olive green, while the abdomen is clear white or a very light greenish white. The beak extends to the hind coxæ and is dusky greenish olive, as are also the legs which are of about uniform size, or the hind ones possibly a trifle the larger.

Five fairly distinct sizes or forms representing probably as many stages are included in the series, but there is very little

difference in them except in size, the greater amount of the dark color and the appearance of the wing pads.

Evidently they pass by easy gradations from one instar to another. Probably the moults take place within the froth masses as occasionally moulted skins may be found in the froth masses, but the nymphs appear to move readily from the froth if disturbed and start a new mass at another point. This habit of froth forming is so strong that they will begin the liberation of air bubbles in the balsam solution if placed in it alive for mounting.

The difficulty of securing newly hatched individuals is obvious since the only indication of occurrence is from the masses of froth and these do not appear until the young have fed and presumably have attained some increase in size.

The smallest individuals represent, therefore, probably advanced individuals of the first instar or possibly newly moulted individuals of the second instar. They are about two millimeters long, the head, prothorax, and mesothorax, with legs, antennæ, and last segment of the abdomen dark olive green, the metathorax and abdomen except last segment, greenish white or nearly pure white. There is no trace of enlargement for the wing pads and the metathorax is very short and inconspicuous.

The second size of individuals, probably second instar, show dark color on the metathorax and the angles of meso- and metathorax appear scarcely swollen.

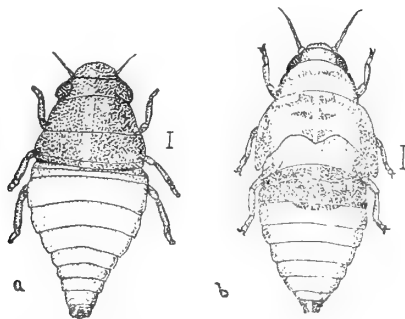


Fig. 43. *Clastoptera proteus* Fitch. Nymphs of 2nd or 3rd and final instar. Enlarged. (Original.)

The next in size, the third instar (?) show extension of mesothorax into the beginning of wingpads, but no perceptible pads on the metathorax. The dark color extends on to the first, second, and middle of the third abdominal segments, but is uniformly dusky on pro- meso- and metathorax.

No distinct separation of fourth and fifth instars has been made, but individuals referred to these differ in having less solid dark marking on the thorax and more extension of color on the abdomen. The wing pads are much more developed, and in the more mature forms extend on to the base of the abdomen. These mature forms, which are about three and a half millimeters in length, give rise to the adults, the appearance of adults coming the latter part of July.

Putting the various records together, it appears that the eggs remain over winter, the nymphs appear in late June, mature by the latter part of July and the adults presumably lay eggs during the latter part of the summer. There seems very little probability of a second brood in the latitude of Orono.

While these insects sometimes occur in considerable abundance and their food plants are often utilized as ornamental shrubs there is little danger of their becoming so serious a pest as to require any particular treatment. Indeed so far as observations go they seem pretty generally confined to the bushes, growing in their natural habitats and have not been taken upon bushes growing under cultivation.

CLASTOPTERA XANTHOCEPHALA GERM.

This small species while more southern in distribution occurs in some parts of New England, and may at times be found in Maine. It is a very small species, about three mm. long, and black or dark brown, resembling the black varieties of *proteus*, but differing in having slender lines across the upper part of the face and the lower part including the clypeus is black.

According to Mr. Heidemann it has been found during the nymphal stages on Chrysanthemums, although he surmises that the original food plant may have been Ragweed. In either case it can hardly be counted as of any particular economic importance in Maine.

Philaronia bilineata Say.

Another species which may be mentioned as belonging to the Maine fauna, although it has not been found in any abundance in the State, is the two-lined spittle insect *Philaronia bilineata* which is a common species through the northern part of the country from the White Mountains to the Rocky Mountain region. It is a little larger and more robust than *Philaenus lineatus* but much like it in general appearance. It has been taken at Fryeburg in the western part of the State by Mr. C. P. Alexander. The species has never been treated as of special economic importance and it is evidently too rare in Maine to need economic attention, but it often occurs in large numbers on the vegetation of the plains in the Dakotas and Montana.

CERCOPIDAE OCCURRING IN MAINE.

A list of the species of this family known to occur in the state may be of service in connection with the study of the leaf-hoppers (Jassoidea) and the studies of the life histories of some of the more important species from an economic standpoint.

The froghoppers are recognized by the conspicuous circle of spines at the tip of the hind tibiae and the species occurring in this region are mostly rather small insects of modest colors, and the young are well known on account of the masses of froth in which they are enclosed.

The tree living or shrub living species are included in the genera *Aphrophora* and *Clastoptera* while the species occurring on grasses or low herbage are included in the genera *Philaenus* and *Lepyronia*.

Aphrophora parallela Say. Occurs on pine, often abundant.

Aphrophora saratogensis Fitch. Also a pine species is less frequent.

Aphrophora quadrinotata Say. Not abundant in collections so far.

Philaenus spumarius L. A very abundant species in meadows and mixed vegetation, living on other plants than grasses.

Philaenus lineatus L. Very common in meadows and grass land living on various species of grass.

Lepyronia quadrangularis Say. Much less common here than the preceding species but evidently not a grass feeding species.

Philaronia bilineata Say, Fryeburg. (C. P. Alexander)

Clastoptera obtusa Say. A common species on alder, etc.

Clastoptera proteus Fitch. Common on dogwood.

Clastoptera xanthocephala Germ.

Of these species only the *Philaenus lineatus* and *Aphrophora quadrinotata* have been given a record for Maine in Ball's Monograph of the North American species, but *spumarius* is recorded for Nova Scotia and "New England States."

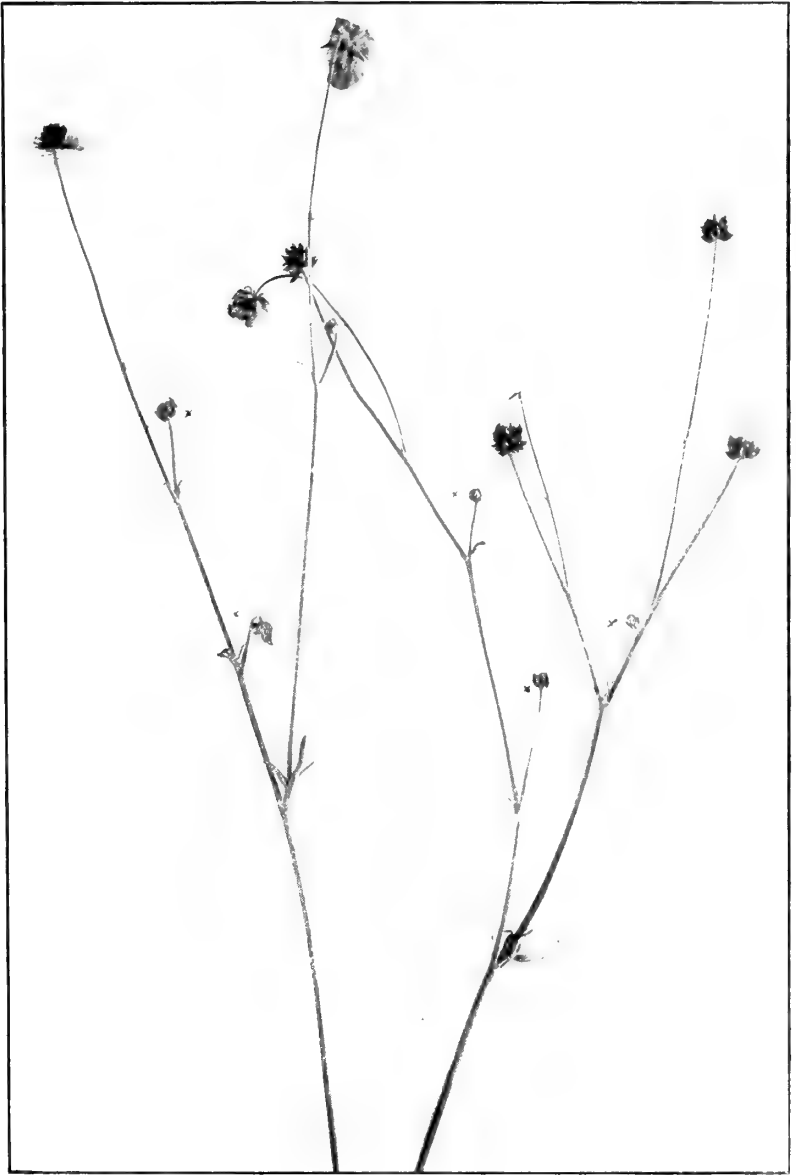


Fig. 44. Buttercup affected by *Philaenus spumarius*. The shriveled blasted heads are indicated by the x. (Original photograph.)



Fig. 45. Buttercup heads enlarged showing the blasting due to attacks of the Froghopper *Philaenus spumarius*. Fig. 46. Female reproductive organs of *Philaenus spumarius* showing ovary with undeveloped, partially developed and mature eggs, the latter appearing very black, with shell. Below these and connected with the oviduct is the circular spermatheca and at bottom the ovipositor. (Original photographs.)

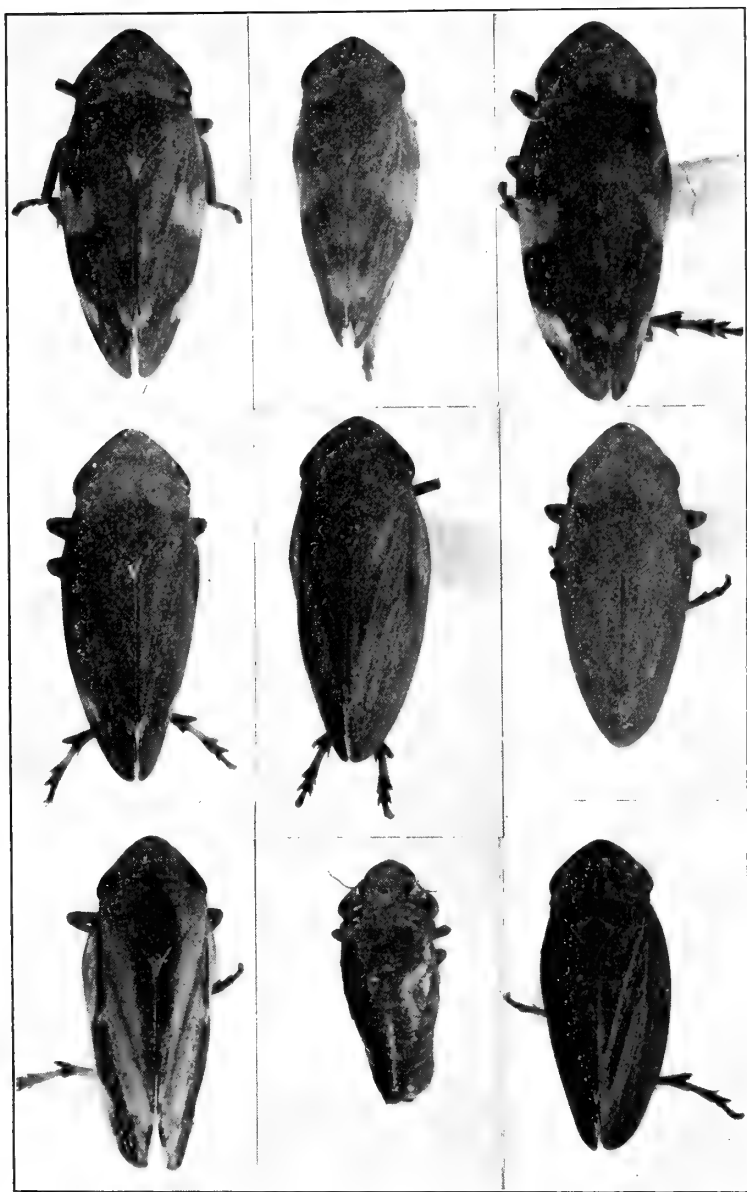
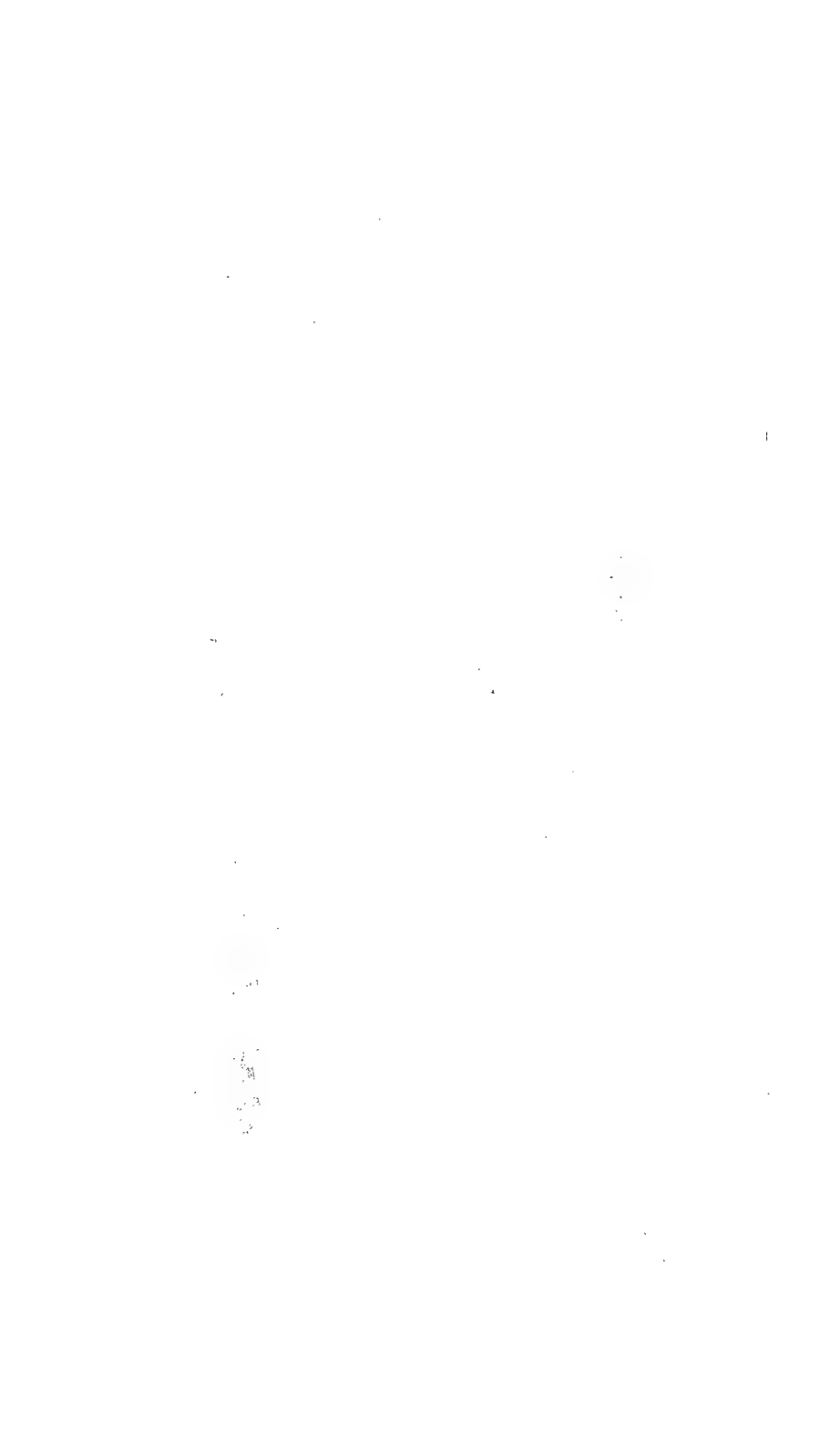


Fig. 47. Varieties of *Philaenus spumarius*. 1, 2, 3, var. *fasciatus*; 4, 6, *leucocephalus*; 5, *pallidus*; 7, *lineatus*; 8, nymph in final (fifth?) instar; 9, dark form of *leucocephalus*. (Original photograph.)



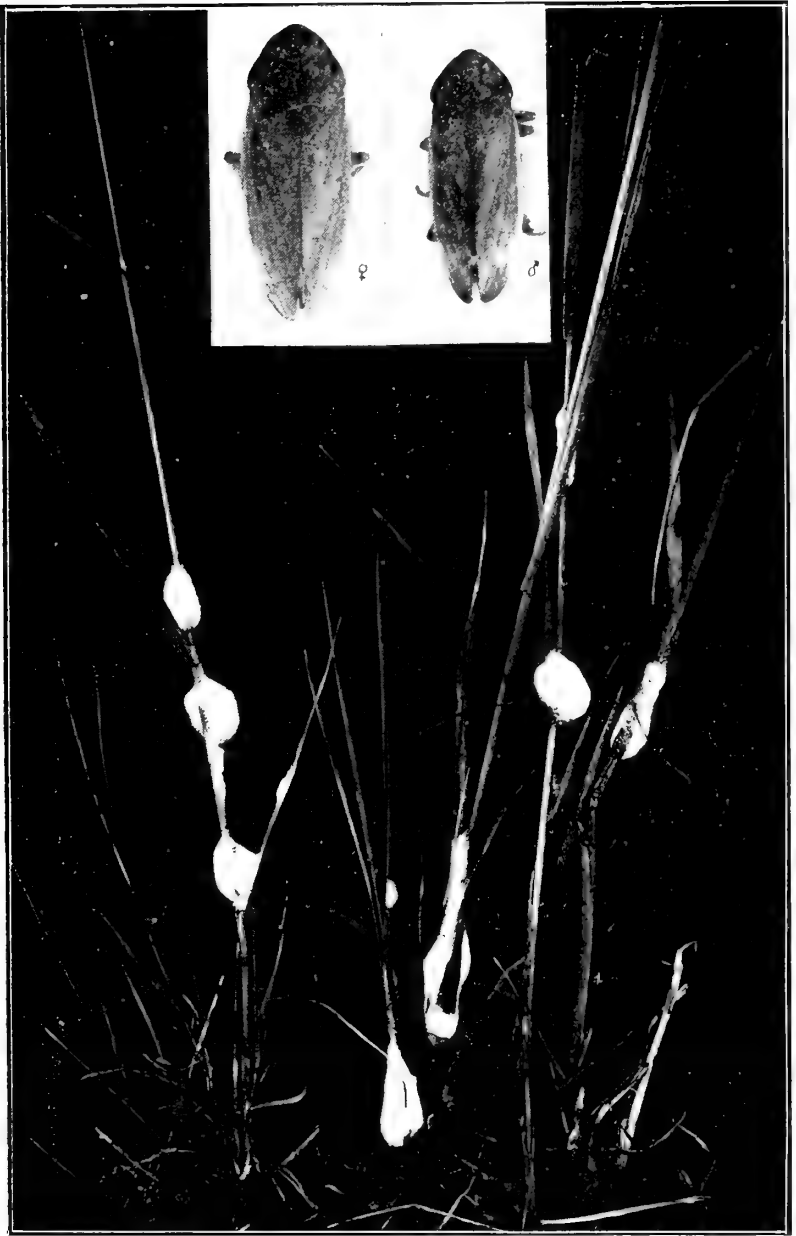


Fig. 48. *Philaenus lineatus*. Male and female above. Grass stems showing froth masses attached about natural size. (Original from photographs.)

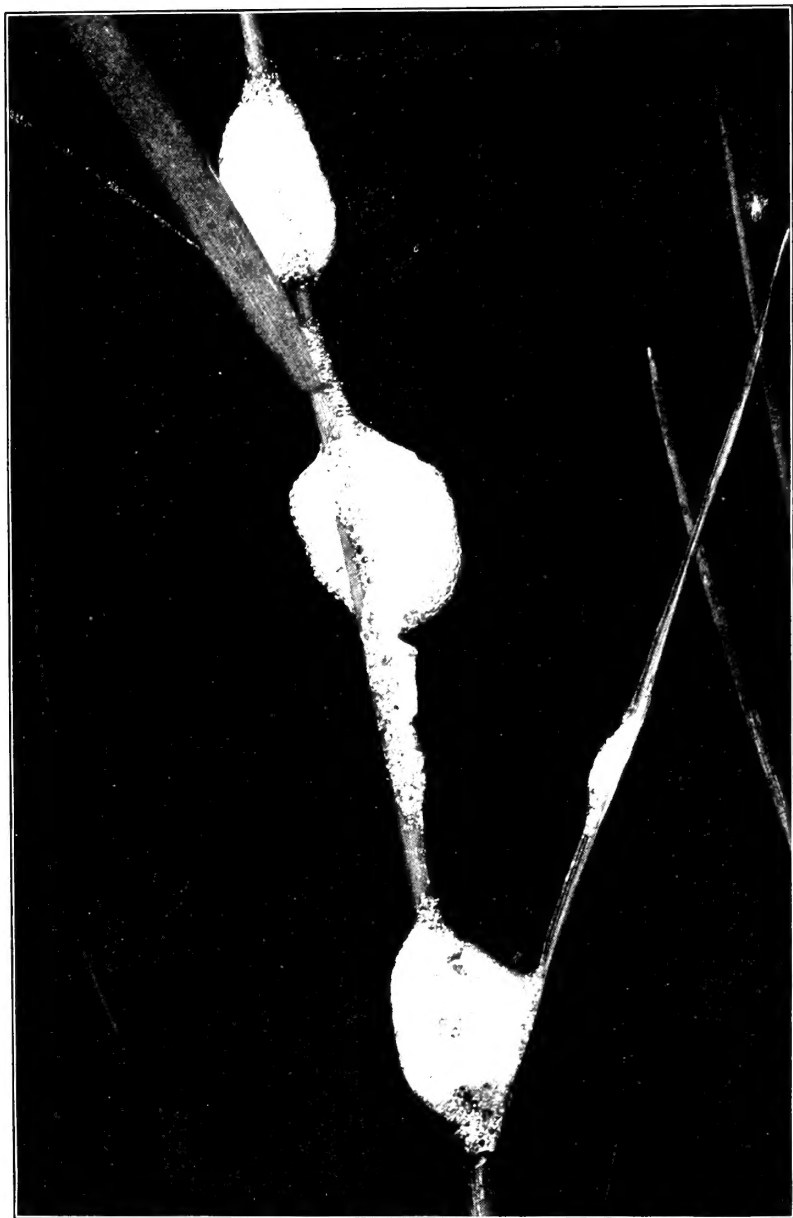


Fig. 49. Froth masses of *Philaenus lineatus* enlarged about three diameters. (Original from photograph.)

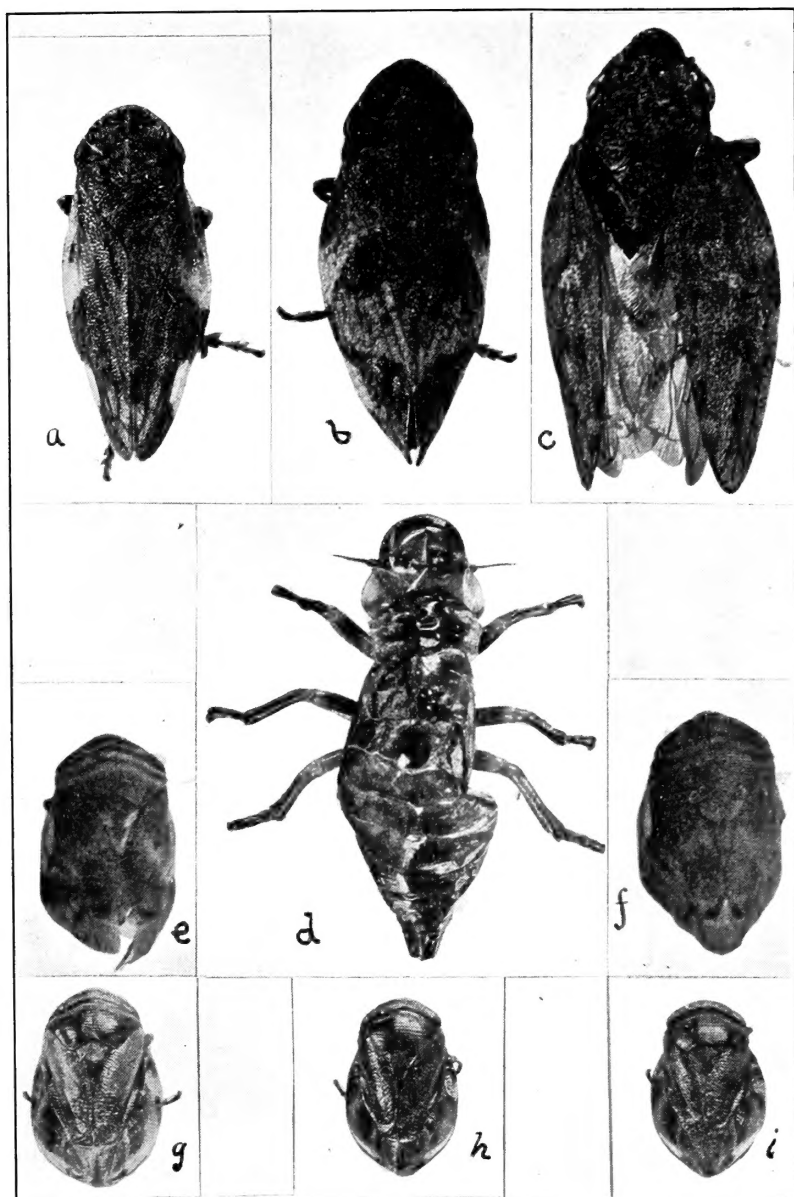


Fig. 50. a, *Aphrophora quadrinotata*; b, *Lepyrionia quadrangularis*; c, *Aphrophora parallela*; d *A. parallela*. Nymphal molt from last instar; *Clastoptera obtusa* Say; e, male; f, female; *Clastoptera proteus* Fitch, g, female; h, i, two varieties of male. (Original.)

